

$$\begin{aligned} k &= \frac{1}{4\pi\epsilon_0} \\ \Delta V &= -\int \vec{E} \cdot d\vec{s} \\ V &= k \frac{q}{r} \\ \Delta U &= q \Delta V \\ I &= dq/dt \\ P &= I \Delta V \\ R &= \frac{\Delta V}{I} \end{aligned}$$

Series :

$$\begin{aligned} \frac{1}{C_{\text{eq}}} &= \sum \frac{1}{C_i} \\ R_{\text{eq}} &= \sum R_i \end{aligned}$$

Parallel :

$$\begin{aligned} \frac{1}{R_{\text{eq}}} &= \sum \frac{1}{R_i} \\ C_{\text{eq}} &= \sum C_i \end{aligned}$$

$$\begin{aligned} \vec{E} &= k \frac{q}{r^2} \hat{r} \\ \vec{F} &= k \frac{q_1 q_2}{r^2} \hat{r} \\ \vec{F} &= q \vec{E} \\ \vec{p} &= q \vec{d} \\ \vec{\tau} &= \vec{p} \times \vec{E} \\ U &= -\vec{p} \cdot \vec{E} \\ |\vec{E}| &\propto \frac{|\vec{p}|}{r^3} \\ \Phi_E &= \int \vec{E} \cdot d\vec{A} \\ \epsilon_0 \oint \vec{E} \cdot d\vec{A} &= q_{\text{enclosed}} \\ \oint \vec{E} \cdot d\vec{\ell} &= -\frac{d\Phi_E}{dt} \\ C &= \frac{Q}{\Delta V} \\ C &= \epsilon_0 \frac{A}{d} \\ U &= \frac{1}{2} C [\Delta V]^2 \\ R &= \rho \frac{\ell}{A} \\ \tau_C &= RC \\ u_E &= \frac{1}{2} \epsilon_0 E^2 \end{aligned}$$

$$\begin{aligned} \vec{B} &= \frac{\mu_0 q}{4\pi} \frac{\vec{v} \times \hat{r}}{r^2} \\ d\vec{B} &= \frac{\mu_0 I}{4\pi} \frac{d\vec{\ell} \times \hat{r}}{r^2} \\ \vec{F} &= q \vec{v} \times \vec{B} \\ \vec{F} &= I \vec{\ell} \times \vec{B} \\ \vec{\mu} &= NI \vec{A} \\ \vec{\tau} &= \vec{\mu} \times \vec{B} \\ U &= -\vec{\mu} \cdot \vec{B} \\ \Phi_B &= \int \vec{B} \cdot d\vec{A} \\ \oint \vec{B} \cdot d\vec{A} &= 0 \\ \oint \vec{B} \cdot d\vec{\ell} &= \mu_0 (I_c + I_d) \\ L &= \frac{\Phi_B}{I} \\ L &= \mu_0 N^2 \frac{A}{\ell} \\ U &= \frac{1}{2} LI^2 \\ B &= \mu_0 n I \\ \tau_L &= L/R \\ u_B &= \frac{1}{2\mu_0} B^2 \end{aligned}$$

$$\begin{aligned} q &= q_{\text{max}} \left(1 - e^{-t/\tau_c} \right) \\ q &= q_0 e^{-t/\tau_c} \\ I &= I_{\text{max}} \left(1 - e^{-t/\tau_L} \right) \\ I &= I_0 e^{-t/\tau_L} \\ I &= \int \vec{J} \cdot d\vec{A} \\ \vec{J} &= \sigma \vec{E} \\ \mathcal{E} &= -N \frac{d\Phi_B}{dt} \\ I_d &= \epsilon_0 \frac{d\Phi_E}{dt} \\ \mathcal{E} &= -L \frac{dI}{dt} \\ c &= f\lambda = \frac{|\vec{E}|}{|\vec{B}|} \\ \vec{S} &= \frac{1}{\mu_0} \vec{E} \times \vec{B} \\ I &= \frac{P}{4\pi r^2} \\ P_r &= \frac{(2)I}{c} \\ I_{\text{trans}} &= I_0 \cos^2 \theta \end{aligned}$$

Fundamental Charge $e = 1.602 \times 10^{-19} \text{ C}$
 Coulomb constant $K = 8.988 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$
 Earth's gravitational field $g = 9.81 \text{ N/kg}$

Mass of an Electron $m_e = 9.109 \times 10^{-31} \text{ kg}$
 Vacuum Permittivity $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$
 Vacuum Permeability $\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$

Unless otherwise directed, friction, drag, and gravity should be neglected, and all batteries and wires are ideal.
 All integrals in free-response problems must be evaluated.

Recitation Sections

STUDENT IDENTIFICATION

George P. Burdell

123 900987654

WRITTEN information for human benefit

Test Form Number from YOUR test

column 4 is blank

YOUR student number starts in column 5

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Version

Quiz #2 Form #221

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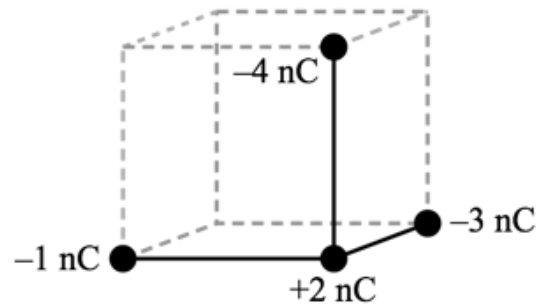
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Physics 2212 GJ Fall 2015

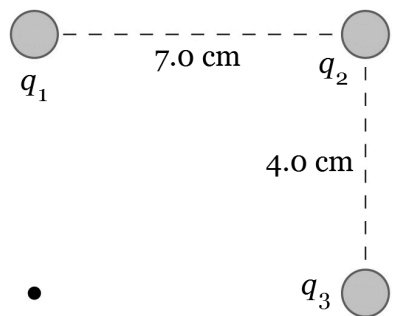
Recitation Section: _____

- Print your name, quiz form number (3 digits at the top of this form), and student number (9 digit Georgia Tech ID number) in the section of the answer card labeled “Student Identification.”
- Bubble the Quiz Form Number in columns 1–3, skip column 4, then bubble your Student Number in columns 5–13.
- Free-response questions are numbered I–III. For each, make no marks and leave no space on your card. Show all your work clearly, including all steps and logic. Box your answer.
- Multiple-choice questions are numbered 1–10. For each, select the answer most nearly correct, circle this answer on your quiz, and bubble it on your answer card. Do not put any extra marks on the card.
- Turn in your quiz and answer card as you leave. Your score will be posted when your quiz has been graded. Quiz grades become final when the next quiz is given.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.

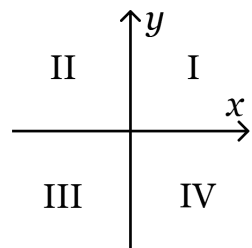
I. (17 points) Four charges (-1.0 nC , $+2.0\text{ nC}$, -3.0 nC , and -4.0 nC), each with mass 0.10 g , are brought together and fixed at adjacent corners of a cube of edge length 1.0 mm , as shown. The -4.0 nC charge breaks free and accelerates away. How fast does it ultimately end up going?



- II. (16 points) Three point charges, $q_1 = -3.5 \mu\text{C}$, $q_2 = +12 \mu\text{C}$, and $q_3 = +4.5 \mu\text{C}$, are situated at three corners of a rectangle as shown. What is the electric potential at the free corner where there is no charge?
Announced during quiz: Potential is zero at infinite distance.

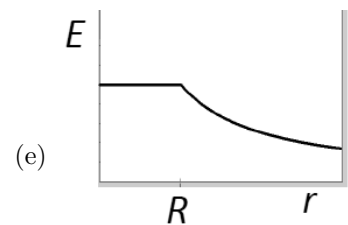
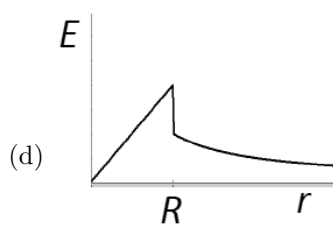
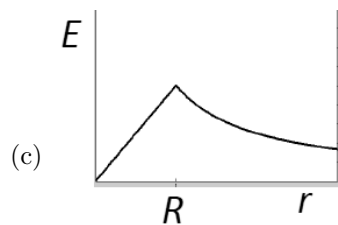
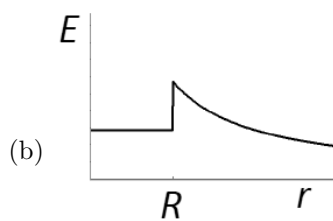
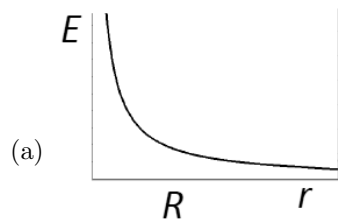


1. (5 points) In the problem above, in what quadrant, if any, is the direction of the potential at the free corner?
- (a) The potential has no direction.
 - (b) The potential is directed in quadrant *I*.
 - (c) The potential is directed in quadrant *III*.
 - (d) The potential is directed in quadrant *II*.
 - (e) The potential is directed in quadrant *IV*.



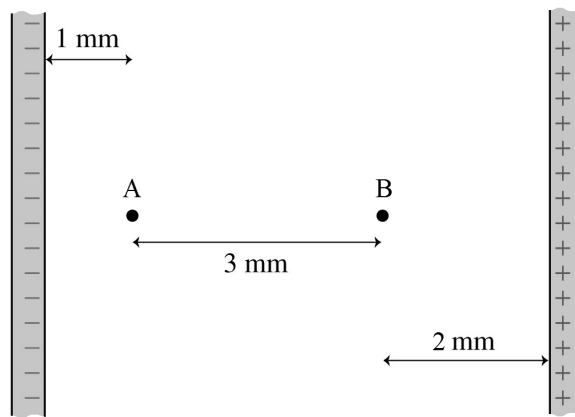
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- III. (17 points) An infinitely long, straight non-conducting cylinder (radius R) has a uniform charge per unit volume ρ . Use Gauss' Law to find an expression for the electric field at a point outside the cylinder, a distance r from the cylinder's axis. Express your answer as a function of the variable r and the fixed parameters R and ρ (as well as any necessary constants such as ϵ_0 and π).

2. (5 points) Suppose one wanted to graph the magnitude of the electric field as a function of r , for all values of r (that is, including points inside the charged cylinder). Which of the following sketches best represents the situation?



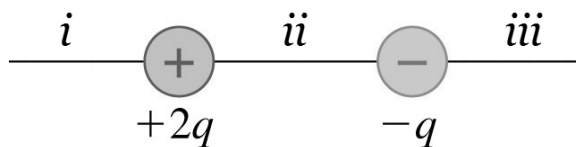
3. (5 points) Two effectively infinite parallel plates, 6 mm apart, form a capacitor with the negative plate on the left, as shown. Point A is 1 mm from the negative plate and point B is 2 mm from the positive plate. Letting the potential be zero at the negative plate, what is V_A/V_B , the ratio of the potential at point A to that at point B ?

- (a) $V_A/V_B = 1/3$
- (b) $V_A/V_B = 1$
- (c) $V_A/V_B = 1/4$
- (d) $V_A/V_B = 4$
- (e) $V_A/V_B = 3$



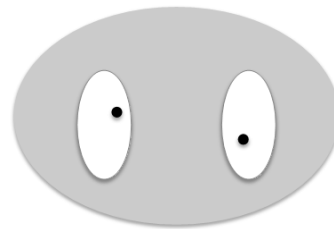
4. (5 points) Where on the horizontal axis, other than at $\pm$ infinity, is the potential equal to zero? Define zero potential as the potential at infinity.

- (a) At a point in region ii and at a point in region iii .
- (b) Only at a point in region i .
- (c) Only at a point in region iii .
- (d) Only at a point in region ii .
- (e) At a point in region i and at a point in region ii .



-
5. (5 points) A chunk of metal has two hollow cavities (see figure). The metal itself carries net charge of -5 nC . The right cavity contains a point charge $+2\text{ nC}$, while the left cavity contains a point charge -3 nC . What is the net charge on the outer surface of the metal?

- (a) -1 nC
- (b) -6 nC
- (c) zero
- (d) -4 nC
- (e) -5 nC



-
6. (5 points) Two positive charges, with masses $m_1 = 1.0\text{ g}$ and $m_2 = 2.0\text{ g}$, are held a distance d apart. They are released simultaneously and accelerate away from each other, ending up with speeds v_1 and v_2 , respectively. How are v_1 and v_2 related?

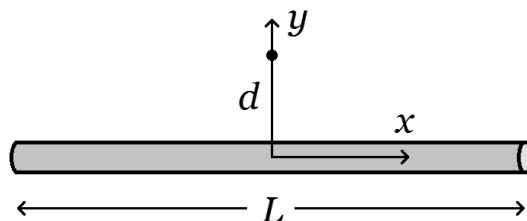
- (a) $v_1 = v_2$
- (b) It cannot be determined, because the relationship between v_1 and v_2 depends on d .
- (c) $v_1 < v_2$
- (d) $v_1 > v_2$
- (e) It cannot be determined, because the relationship between v_1 and v_2 depends on the charges q_1 and q_2 .

-
7. (5 points) A thin rod of length L lies on the x axis with its center at the origin. It has a linear charge density λ that varies with position x according to

$$\lambda = \lambda_0 \frac{x}{L}$$

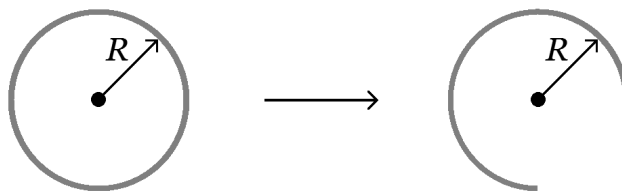
where λ_0 is a constant. What is the electric potential due to the rod, with respect to zero at infinity, at a point located at d on the $+y$ axis?

- (a) $K\lambda_0 L/d$
- (b) zero
- (c) $K\lambda L/d$
- (d) $K\lambda_0/d$
- (e) $K\lambda/d$



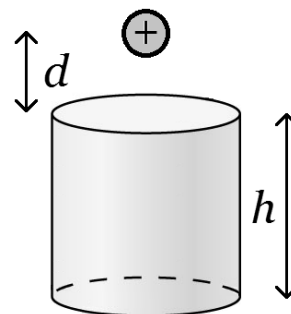
-
8. (5 points) The potential at the center of a uniformly charged ring is V_0 (relative to zero at infinity). If $1/4$ of the ring is removed, as shown below, what will be the new potential at the same position?

- (a) $V_0/\sqrt{2}$
- (b) $V_0/2$
- (c) V_0
- (d) $V_0/4$
- (e) $3V_0/4$



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9. (5 points) A positively charged particle lies on the axis of a cylindrical surface, a distance d from one end, as shown. The cylinder has height h . Compare the *magnitude* of the electric flux through the top and bottom surfaces of the cylinder.

- (a) $|\Phi_{\text{top}}| < |\Phi_{\text{bottom}}|$ if $d < h$, but $|\Phi_{\text{top}}| > |\Phi_{\text{bottom}}|$ if $d > h$
 (b) $|\Phi_{\text{top}}| > |\Phi_{\text{bottom}}|$
 (c) $|\Phi_{\text{top}}| = |\Phi_{\text{bottom}}|$
 (d) $|\Phi_{\text{top}}| < |\Phi_{\text{bottom}}|$
 (e) $|\Phi_{\text{top}}| > |\Phi_{\text{bottom}}|$ if $d < h$, but $|\Phi_{\text{top}}| < |\Phi_{\text{bottom}}|$ if $d > h$



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10. (5 points) A positively charged particle and a negatively charged particle, each having charge magnitude q , lie on the axis of a cylindrical surface, equidistant from the ends, as shown. Rank the flux through the top, side, and bottom of the cylinder, from greatest to least. Remember that electric flux can be positive or negative.

- (a) $\Phi_{\text{bottom}} > \Phi_{\text{side}} > \Phi_{\text{top}}$
 (b) $\Phi_{\text{top}} = \Phi_{\text{side}} = \Phi_{\text{bottom}}$
 (c) $\Phi_{\text{top}} > \Phi_{\text{side}} > \Phi_{\text{bottom}}$
 (d) $\Phi_{\text{top}} = \Phi_{\text{bottom}} > \Phi_{\text{side}}$
 (e) $\Phi_{\text{side}} > \Phi_{\text{top}} > \Phi_{\text{bottom}}$

